CHINA SPALLATION NEUTRON SOURCE

Status of CSNS Project

Shinian FU

for CSNS Team

Institute of High Energy Physics CAS

CSNS CHINESE ACADEMY OF SCIENCES

On PAC09, Vancouver, Canada, 4-8,May,2009

Contents

1, Project Overview

Project Overview

Why a spallation neutron source in China?

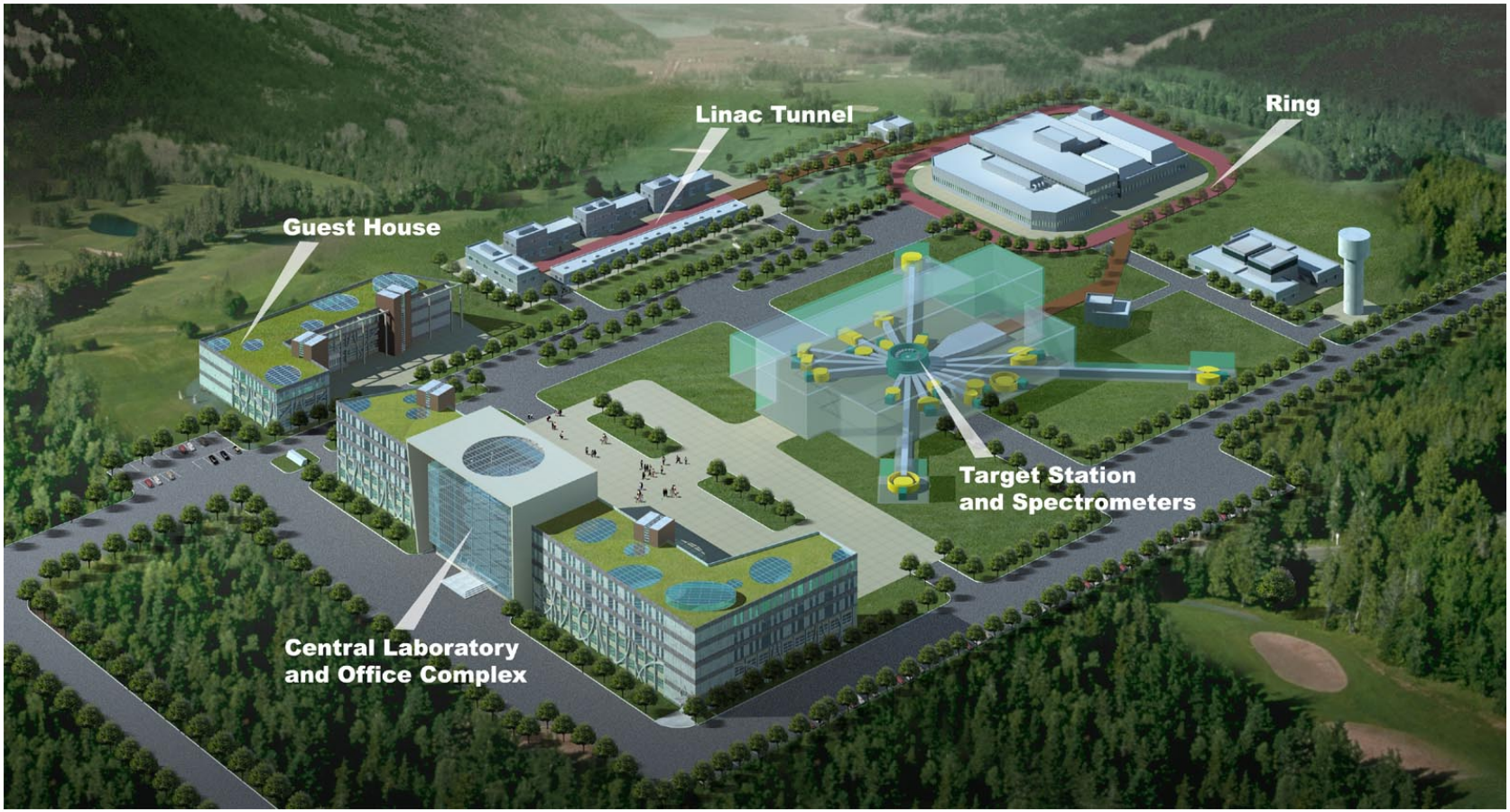
- There are three synchrotron radiation light sources in PRC, but no spallation neutron source.
- A 60MW reactor CARR will soon commission at CIAE in 2009. It provides continues neutron beams for researches.
- CSNS is demanded by a large user community in multidiscipline research, because it is a complement to SR and reactor.
- CSNS can also promote the development of ADS (Accelerator Driver Subcritical system) in China, which is recognized as the best option for nuclear waste transmutation for nuclear power station.
- The CSNS accelerator technology can be transferred to proton therapy.

Project Overview

Milestones

- 2005. 6: “political approval” (CD-0)
  - central government approval & fund allocation
- 2006.1 -: CAS funded R&D 1 (35 M CNY)
- 2007.7 -: Guangdong funded R&D 2 (40 M CNY)
- 2007.12 -: “project establishment review”
  - Budget baseline: 1.4 B CNY + 0.5 B CNY (Guangdong) + land
- 2008.6: environmental impact assessment completed
- 2008.9: “project establishment approval” (CD-1)
- 2010: ground breaking expected
  - Need to pass feasibility review and preliminary design reviews

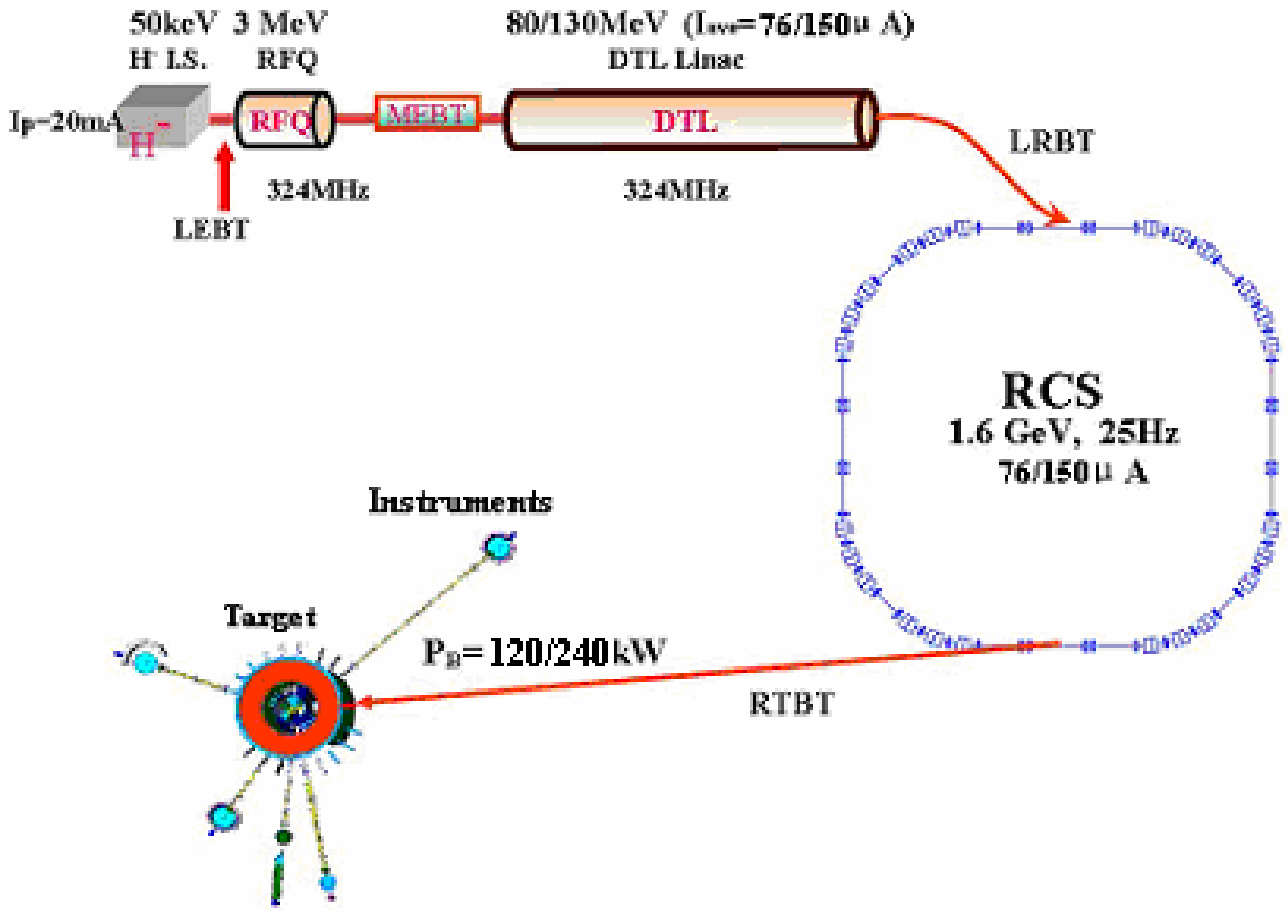
Project Overview



CSNS in Guangdong will be a new branch of IHEP, with 450 new positions.

Project Overview

CSNS facility layout

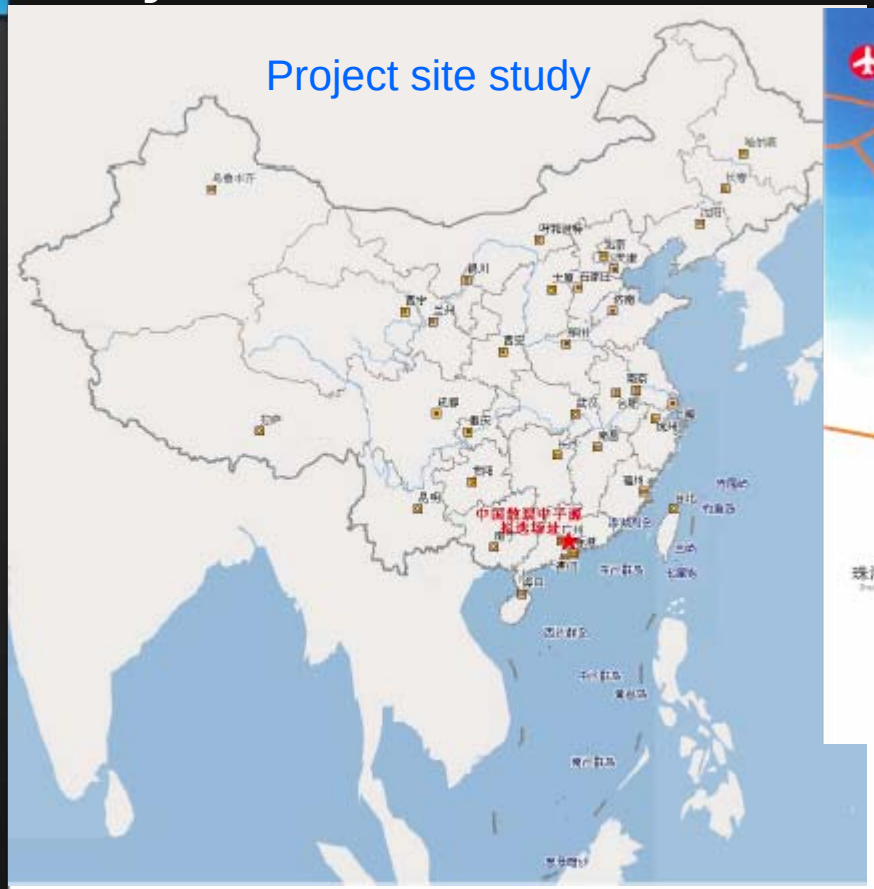


Project Overview

Primary design parameters

Phase	I	II	II'
Beam power on target [kW]	120	240	500
Beam energy on target [GeV]	1.6	1.6	1.6
Ave. beam current [μA]	76	151	315
Pulse repetition rate [Hz]	25	25	25
Protons per pulse [10^{13}]	1.9	3.8	7.8
Linac energy [MeV]	81	132	230
Linac type	DTL	DTL	DTL+SCL
Target number	1	1	2
Target material	Tungsten		
Moderators	H_2O (300K), H_2(20K)		
Number of spectrometers	3	18	18

Project Overview



CSNS is the first large scientific facility in southern part of China. It can balance the present uneven distribution of the facility, and promote advanced researches in the economic developed zone of Guangdong-Hongkong.

Project Overview

- CSNS is located in a well-developed zone of science and high-tech park- Song San Lake.

Project Overview

Design philosophy

- Fit in China's present economical situation
  - Total phase-I cost ~1.46B CNY (~US$188M)
- An advanced facility with upgrade potential
  - Phase I beam power goal: 120 kW; phase II: 240 kW
  - Expandable to higher power/2nd target
- Adopt mature technology as much as possible
  - First high-intensity proton machine in China
  - High reliability for our users
- Closely collaborate with world leaders & develop domestic technology to control cost
  - Keep final fabrication in China as much as possible

2, Accelerator Design

Accelerator Design

- **Accelerator major design parameters**

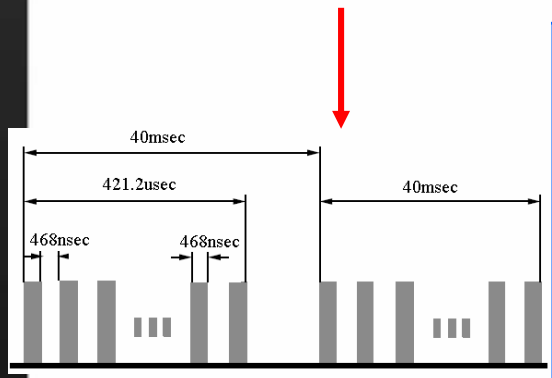
	Phase I	Phase II
Beam power on target [kW]	120	240
Proton energy on target [GeV]	1.6	1.6
Average beam current [μA]	76	151
Pulse repetition rate [Hz]	25	25
Peak ion source H- current [mA]	20	40
Peak linac H- current [mA]	15	30
Chopper bean-on duty factor [%]	50	50
Linac energy [MeV]	80	132
Linac type	DTL	DTL
Linac RF frequency [MHz]	324	324
Linac beam duty [%]	1	1
RCS ring circumference [m]	230	230
RCS harmonic number	2	2
Ring RF frequency [MHz]	1.01 ~2.4	1.01 ~ 2.4
Maximum cycling current [A]	3.6	7.2
Protons per pulse [10^{13}]	1.9	3.8

Accelerator Design

- Hands-on maintenance: ~ 1 W / m uncontrolled beam loss
- Upgradeable with increased injection energy
- 4-fold symmetry: separated injection, extraction, collimation straights
- FODO arc and doublet straight
- Both localized & 2-stage momentum collimation possible
- Multi-turn injection with dc chicane for simplified design
- One-turn extraction without bump

Accelerator Design

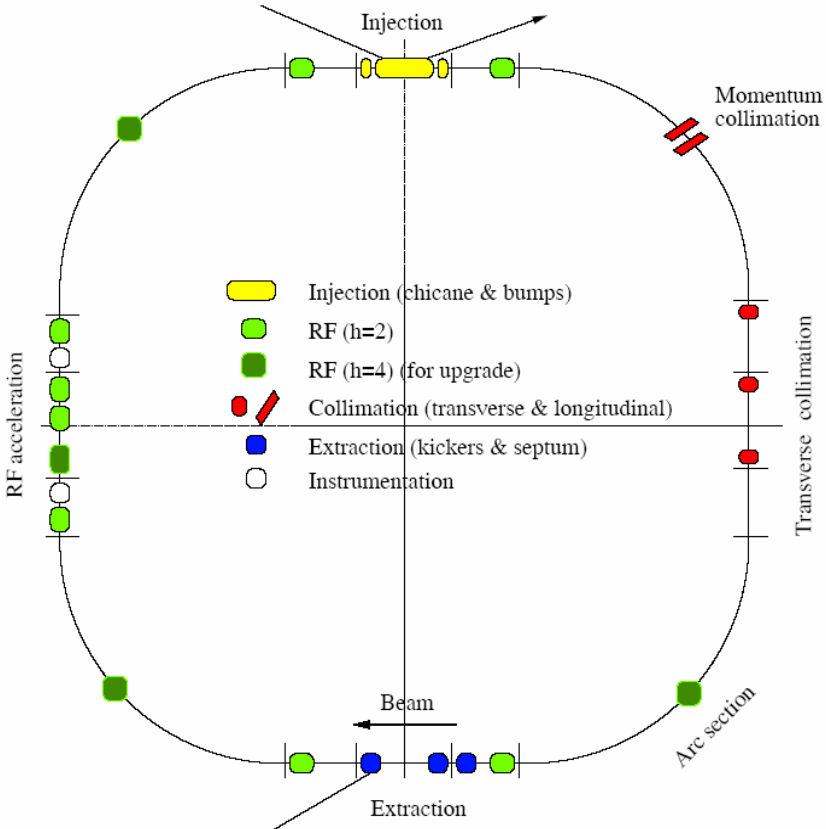
- 324MHz Linac, with additional tunnel for upgrade

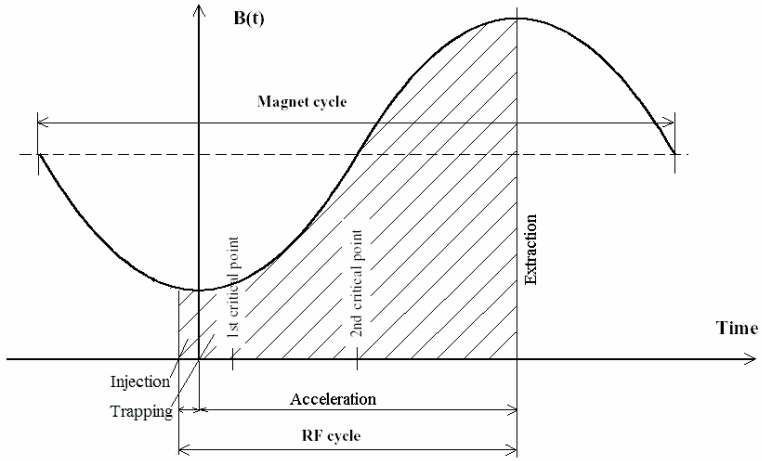


Tank number	1	2	3	4	5	6	7	total
Energy (MeV)	21.8	41.7	61.3	80.8	98.9	116	132.2	132.2
Tank length (m)	7.99	8.34	8.5	8.85	8.69	8.57	8.67	59.6
Number of cell	61	36	29	26	23	21	20	216
RF driving power (MW)	1.41	1.41	1.39	1.45	1.45	1.45	1.49	10.05
Total RF power (MW)	1.97	2.01	1.98	2.03	1.99	1.96	1.98	13.92
Accelerating field (MV/m)	2.06 to 3.1	3.1	3.1	3.1	3.1	3.1	3.1	
Synchronous phase	-30 to -25	-25	-25	-25	-25	-25	-25	

Accelerator Design

•Rapid cycling synchrotron layout





The magnetic field cycle and beam manipulation phases in the RCS

Four major functions--- injection, acceleration, collimation and extraction are arranged in the four dispersion-free straight sections.

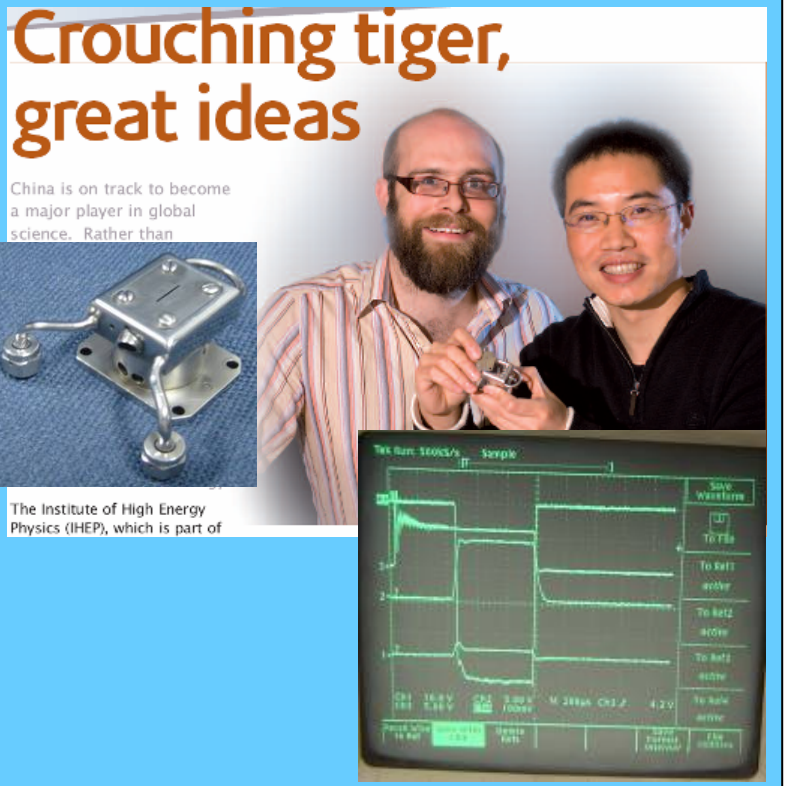
3, R&D Activities

R&D

- **Two Phases R&D:**

1. **2006-2007, $3.8M from CAS**
2. **2007-2008, $5M from Guangdong local government.**

R&D



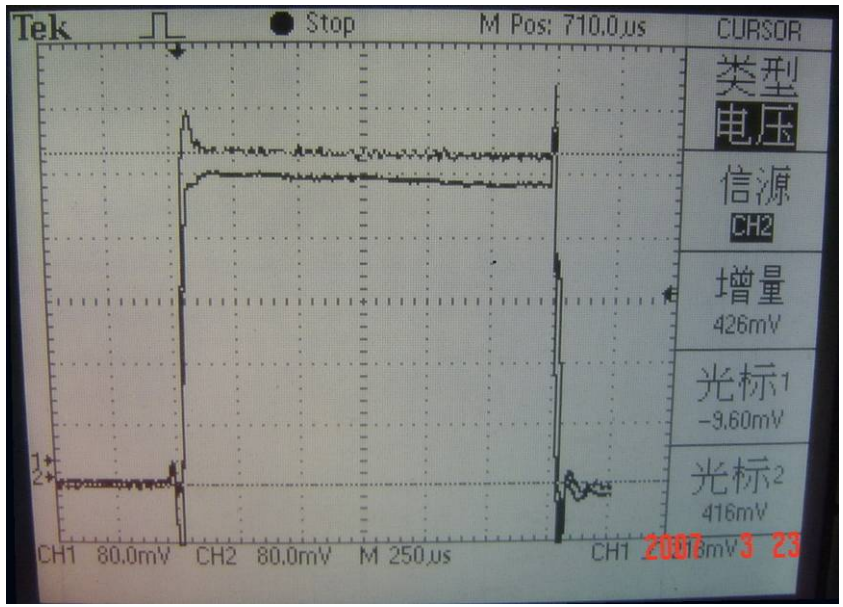
H- ion source: four H- ion source bodies were fabricated at IHEP and test at ISIS with a satisfactory results (55mA pulse current).

A test stand is constructing at IHEP for long-term reliability verification of the ion source.

R&D

WE4PBC03

- **RFQ technology has been developed in an ADS program**

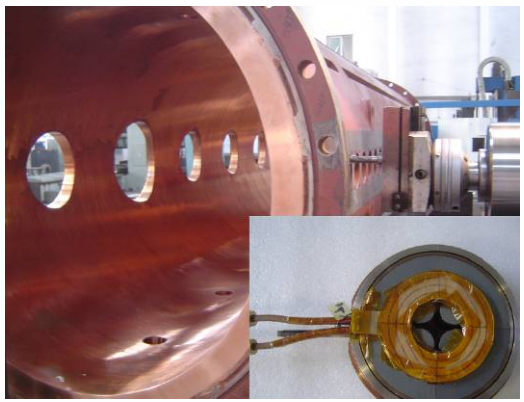


A 3.5MeV RFQ has been commissioned at IHEP with the kind support of the RF power system from CERN.

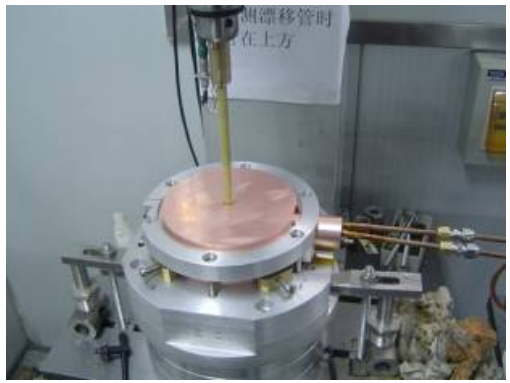
46mA output beam at 7% duty factor, transmission rate>93%. Now to 15% duty.

R&D

- **DTL tank: explosive bonding and electroform technologies are developed for tank copper liner.**
- **Electroformed coil the same as J-PARC.**



The first module of the first tank is in fabricating as a prototype.

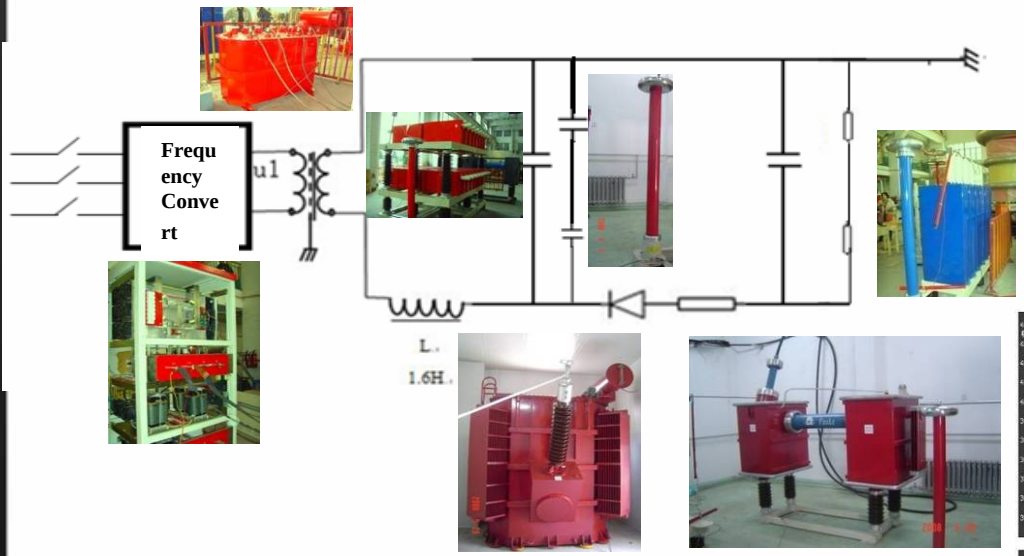


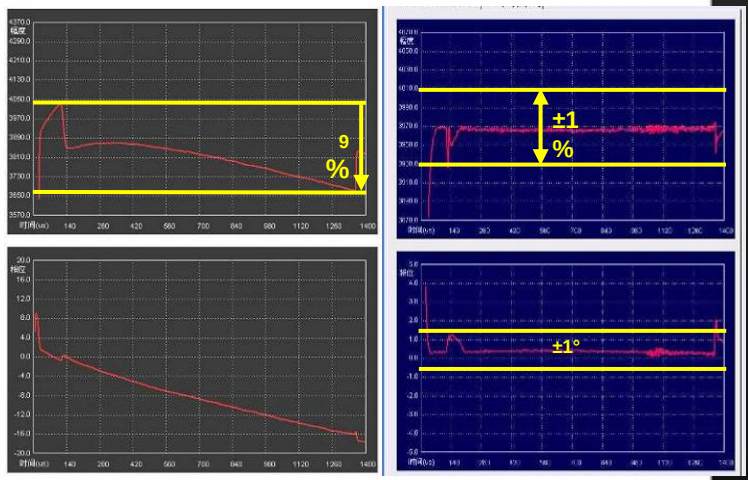
Drift tube by electron welding.

Sakae coil and quadrupole at rotating coil measurement

R&D

Linac RF power system



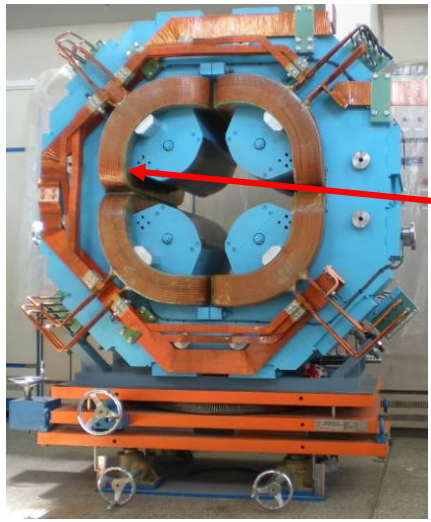


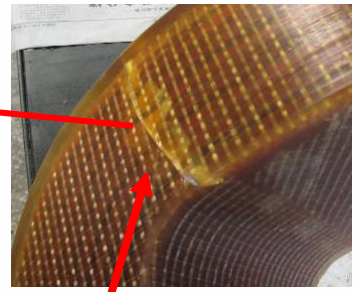
AC resonant HV pulsed power supply for klystron was proposed and devised.

FPGA based digital LLRF control system.

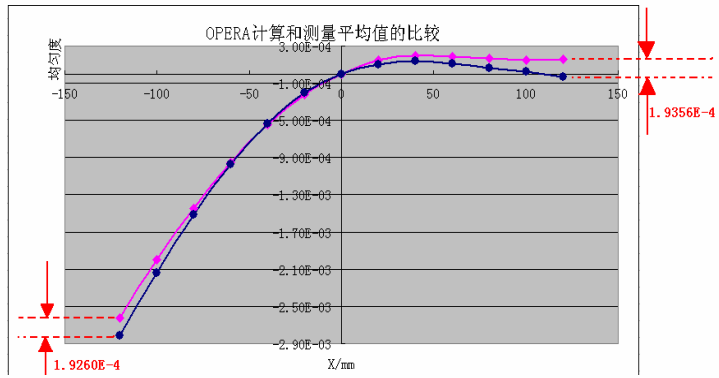
R&D

- **Dipole and quadrupole are prototyped. AC measurement system developed for dipole, with a good preliminary result.**





Problem: cracking in epoxy resin



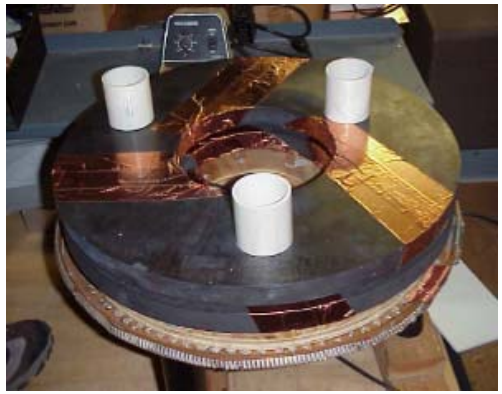
R&D

- **Power supply for dipole magnet**


White resonant circuit was chosen as the power supply for the magnets with a large conductivity. It is composed of DC (1260A)+ AC(900A) sources, choke, and capacitor bank.

R&D

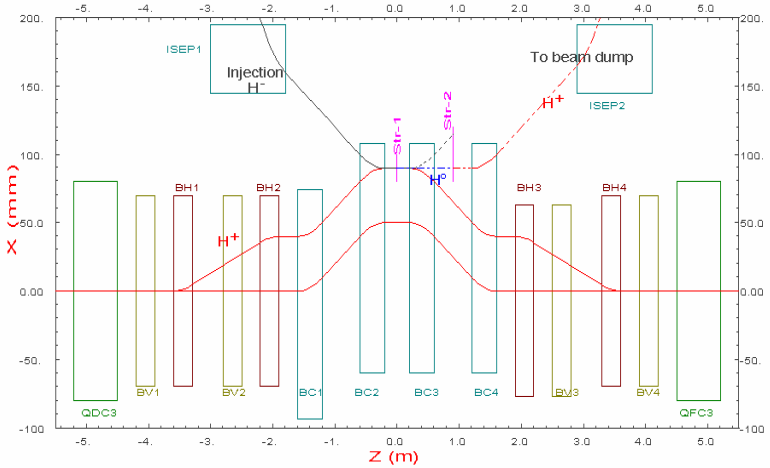
- **A prototype of the ferrite loaded RF cavity: 1 – 2.5 MHz**



Between each ferrite plates is a copper plate with cooling water for heat release. The copper plate is formed by winding a hollow copper conductor.

R&D

- **Injection bumper magnet and power supply are prototyped**



A pulsed power supply with 18,000A output current in maximum during injection time of 500μs connected with the bump magnet for the magnet measurement.

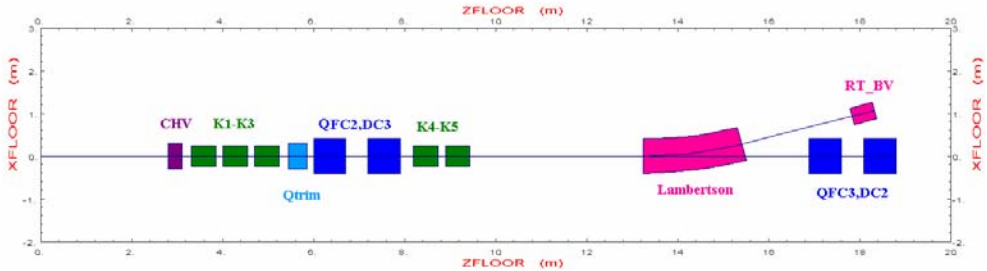
R&D

Extraction

5 twin-C vs. 10 single turn kickers

Merits and demerits for 10 kickers scheme:

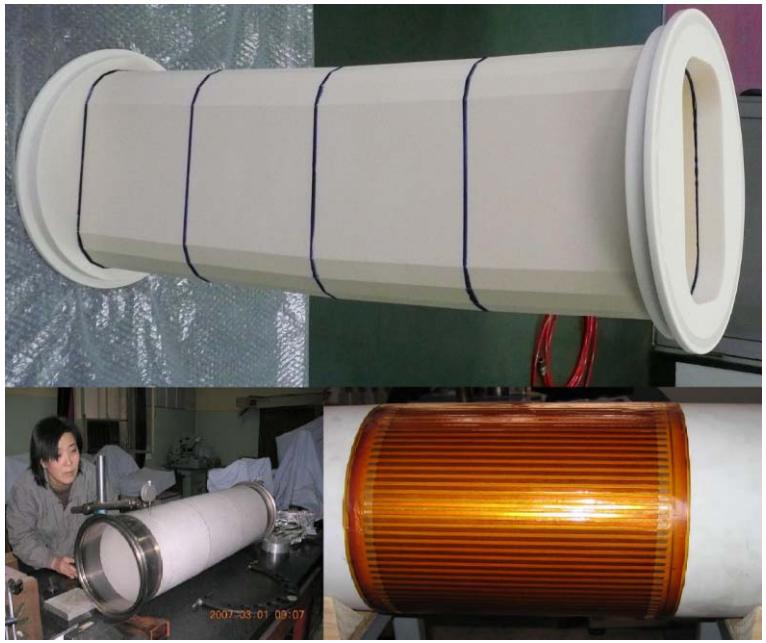
- Ease to kicker magnet and power supply performance
- Less perturbation to beam in case of 1 kicker malfunction
- Extra space and money

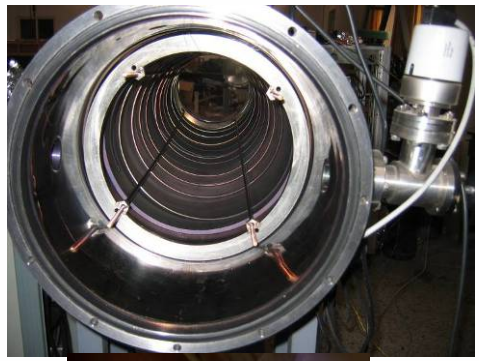


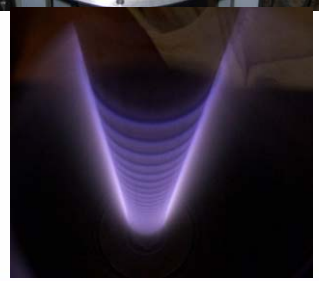
The pulse power supply uses blumlein type pulse forming network to get a short pulse with a current of 5840A and a flattop of better than ±1.5%

R&D

- **Ceramic vacuum chambers for magnets**
  - Ceramic vacuum chamber of large aperture/length
    - Metallic brazing (J-PARC) and glass joint (ISIS)
  - detachable, external metal-strip wrappings for the RF shielding
  - Quadrupole duct developed by domestic vendor
  - Dipole duct: parallel development in progress (assistance from ISIS and J-PARC)







Collaboration

- **CSNS has a wide cooperation with foreign labs:**

1. **LBL**
2. **ANL**
3. **SNS**
4. **BNL**
5. **LANL**
6. **RAL**
7. **CERN**
8. **Julich**
9. **INFN**
10. **KEK & JAEA**
11. **KAERI**
12. **…**

CONCLUSIONS

- CSNS is highly demanded for multidiscipline research in China.
- It will be built in southern part of China, starting in 2010 and completing in 2016.
- It is designed with the capability for upgrade from 120kW to 500kW.
- Most of the key components are under prototyping.
- Calling for more new participants from all the world.
- A close collaboration with world laboratories goes well.

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

Thanks!